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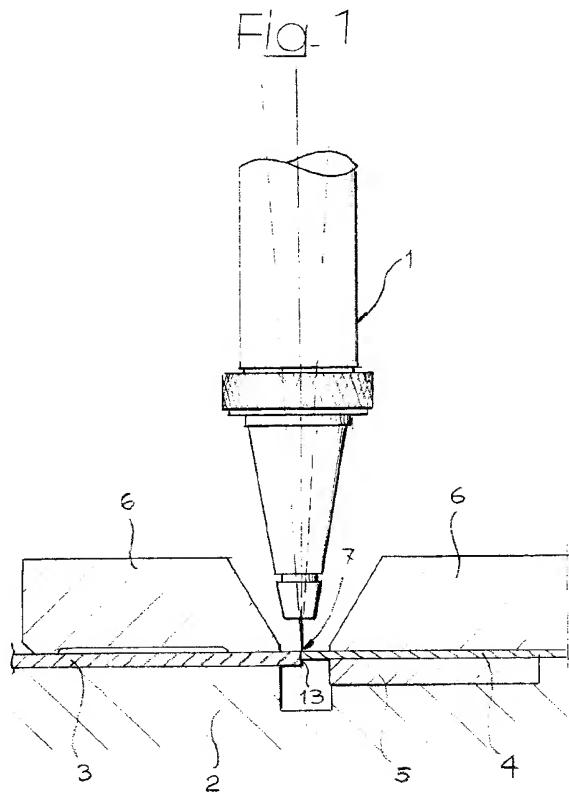
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**(54) Apparatus and method for butt-welding of planar metal sheets of different thickness, by means of a laser beam**

(57) An apparatus for butt-welding of planar metal sheets of different thickness, by means of a laser beam, has two sheet-holding plates (6) urging the metal sheets to be welded (3, 4) against a supporting structure (2), with their surfaces facing towards the laser focusing head (1) lying in the same plane and the opposite surfaces forming a step (13). Before the welding operation

is carried out, when the sheet-holding plates are lowered, one of them causes a plastic deformation of one of the metal sheets to be welded, so as to move one portion thereof to become coplanar with the other metal sheet at the surface opposite to that facing towards the laser focusing head.



## Description

The present invention relates to the field of the apparatus for butt-welding of planar metal sheets of different thickness, by means of a laser beam.

Recently the use has been more and more spreaded, particularly in the automotive industry, of structures obtained from planar elements of sheet metal having different thickness, which are butt welded by means of a laser beam, so as to form a planar blank ("tailored blank") which is then subject to a pressing operation in order to obtain the required configuration. The thickness of the above mentioned elements is chosen as a function of the loads to which the various parts of the final structure thus obtained are subject in use. This technology has a number of advantages with respect to the conventional solution which provides for welding of the various sheet metal elements after that the latter have been pressed so as to give them the requested configurations. The use of the laser beam ensures the good quality of welding and avoids that along the welding line surfaces are originated which project from the planes of the metal sheets, which could give rise to drawbacks in the following operations to which the welded structure is subjected. Welding assembling methods of the above described type are disclosed for example in Japanese Utility Model JP-A-59-182424 and in European Patent EP-B-0 279 866.

During the welding process, the metal sheets with different thickness are held in contact for butt-welding, with their surfaces facing towards the head for focusing the laser beam lying in the same plane, and the opposite surfaces forming a step therebetween. The planar blank thus obtained ("tailored blank") is then subjected to a pressing or drawing operation that provides the final requested configuration. However, the existence of the above mentioned step on one of the two faces of the structure may give rise to some drawbacks, such as the impossibility of welding, on said stepped side, reinforcing plates which extend on both sides of the junction line of the sheet metal elements forming the structure, since these plates cannot rest on a continuous supporting surface. Another application where said step may give drawbacks is that of a motor vehicle back door, where it is necessary to provide a continuous planar surface which is to cooperate with a weather strip arranged on the vehicle body to ensure sealing.

The object of the present invention is that of providing an apparatus of the type indicated at the beginning which is able to overcome said drawbacks.

In order to achieve this object, the invention provides an apparatus for butt-welding of planar metal sheets of different thickness, by means of a laser beam, characterized in that it comprises, in combination:

- a head for focusing a laser beam,
- a structure for supporting the metal sheets to be welded, on which the metal sheets of different thick-

ness are positioned for butt-welding, with their surfaces facing towards the focusing head lying in the same plane and the opposite surfaces forming a step,

- 5 - two sheet-holding plates, for urging the metal sheets to be welded against the supporting structure,
- means for moving the head for focusing the laser beam relative to said structure supporting the metal sheets to be welded, so as to move the laser beam along the contact line between the metal sheets, so that the latter are welded to each other,
- 10 - said supporting structure and at least one of said sheet-holding plates being shaped so that they plastically deform the metal sheet interposed therewith when said sheet-holding plate is pressed against said metal sheet before the welding is carried out.
- 15

20 In a preferred embodiment, the supporting structure and said sheet-holding plate are so shaped as to move a portion of the metal sheet interposed therebetween to be co-planar with the other metal sheet on the side opposite to that facing towards the laser focusing head, so as to nullify said step at said portion, while forming a step on the side facing towards the laser focusing head.

25 The invention also provides a welding process carried out by means of the above described apparatus.

30 The invention will be now described with reference to the annexed drawings, given purely by way of non limiting example, in which:

- 35 figure 1 is a cross-sectional diagrammatic view which shows a preferred embodiment of the apparatus according to the invention,
- figure 2 is a partial perspective view of the welded structure obtained by means of the apparatus according to the invention,
- 40 figure 3 shows a structure obtained from sheet metal elements welded by the apparatus according to the invention,
- figure 4 is a view along arrow IV of figure 3, at an enlarged scale, and
- 45 figures 5, 6 show a perspective view and a plan view of another application of the invention.

With reference to the drawings, reference numeral 1 generally designates a head for focusing a laser beam. The focusing head 1 can be made in any known way 50 and does not fall, taken alone, within the scope of the present invention. The same applies to the structure supporting the focusing head, which includes mirror means for conveying a laser beam coming from a laser generator of any known type (not shown) into the focusing head. The details of construction relative to these parts, which are known *per se*, have not been shown herein, also to render the drawings more easy and simple to understand.

The apparatus according to the invention further comprises a supporting structure 2, which also can be made in any known way, on which two planar metal sheets 3, 4 having different thickness are supported. Metal sheet 4 rests on the supporting structure 2 with the interposition of an element 5 which is so shaped as to keep surfaces 3a, 4a of metal sheets 3, 4 which face towards the focusing head 1 in the same plane, even if metal sheets 3, 4 have a different thickness. Once the metal sheets 3, 4 have been positioned on the supporting structure 2, they are pressed thereagainst by two sheet-holding plates 6. Pushing means are associated with the sheet-holding plates 6 which push these plates against metal sheets 3, 4. Such means can be made in any known way (for example by hydraulic jacks), as it will be clearly apparent to the men skilled in the art. Therefore, also in this case, such details have been eliminated from the drawings, for sake of clarity.

With the laser focusing head 1 and the supporting structure 2 there is associated a displacing means which is able to move the laser focusing head 1 relative to the supporting structure 2, so as to move the laser beam throughout the whole length of the contact line 7 between the two metal sheets 3, 4, to carry out the welding operation. For example, this result may be obtained by providing the laser focusing head 1 on a fixed supporting structure and by mounting the supporting structure 2, with the associated sheet-holding plates 6, on a slide movable along a horizontal direction with respect to the structure supporting the laser focusing head 1. Again, the details of construction relating to this arrangement have been eliminated for sake of clarity, since they are clearly apparent to the skilled technicians.

According to the known technology which has been described, the two metal sheets 3, 4 are welded to each other by means of a laser beam in their planar configuration, whereupon they are subjected to a pressing or drawing operation to provide the requested structure.

Figure 3 of the annexed drawings shows in an exploded view an upright 8 which is formed by two structures 9 of welded and pressed sheet metal, having flanges 10 which are to be welded to each other (shown spaced apart from each other in figure 3). Each structure 9 is formed from two initially planar sheet metal elements 3, 4 which are welded in the above described way (figure 1) and then subjected to a pressing operation. As indicated already, the two elements 3, 4 are welded to each other by holding such elements in the same plane at their surfaces facing towards the laser focusing head 1 during the welding operation. These surfaces are those corresponding to the surfaces of flanges 10 which are facing to each other in figure 3. Therefore, these flanges may be welded to each other, since each of them has a continuous planar surface. Each structure 9 however has a step 13 on its opposite side, since sheet metal element 3 has a thickness which is greater than that of sheet metal element 4. This would prevent a reinforcing plate 14 which extends on both sides of the junction

line 7 of the two elements 3, 4 to be welded on this side of structure 9.

To overcome this drawback, element 5 shown in figure 1, and sheet-holding plate 6 associated therewith, 5 are so shaped as to plastically deform the metal sheet 4 out of its plane in its central portion, as shown at an enlarged scale in figure 2. As shown, the deformation which is obtained renders the two metal sheets coplanar at their faces opposite to those facing towards the laser 10 focusing head, so as to nullify said step 13 at said central portion, while forming a new step on the opposite side (see also figures 3, 4). In other words, the lowering operation of the sheet-holding plates which is carried out immediately before the beginning of the welding operation 15 also causes a plastic deformation of the metal sheet 4 according to the configuration shown in figure 2, so as to provide at the central portion of structure 9 a continuous planar surface on which the reinforcing plate 14 can be welded.

Figures 5, 6 show the application of the invention to 20 a portion of a motor vehicle back door. Due to the invention, the two elements 3, 4 have at their central portion a continuous planar surface, which is to cooperate with a weather strip fixed to the motor vehicle body along the 25 edge of the rear opening of the vehicle back door. On the sides of elements 3, 4, the continuous planar surface is on the opposite side, to enable a counter-plate 20 to be welded thereto.

Naturally, while the principle of the invention remains the same, the details of construction and the embodiments may widely vary with respect to what has been described and illustrated purely by way of example, without departing from the scope of the present invention.

35

## Claims

1. Apparatus for butt-welding of planar metal sheets 40 (3, 4) having a different thickness, by means of a laser beam, characterized in that it comprises, in combination:
  - a head (1) for focusing a laser beam,
  - a structure (2) supporting the metal sheets to be welded (3, 4), on which metal sheets having a different thickness (3, 4) are positioned for butt-welding, with their surfaces (3a, 4a) facing towards the laser focusing head (1) lying in the same plane and their opposite surfaces forming a step,
  - two sheet-holding plates (6), for urging the metal sheets (3, 4) to be welded against said supporting structure (2),
  - means for moving the laser focusing head (1) relative to said structure (2) supporting the metal sheets (3, 4) to be welded, so as to move the laser beam along the contact line (7) of the met-

- al sheets for welding the latter to each other,  
 - said supporting structure (2) and at least one  
 of said sheet-holding plates (6) being shaped  
 so as to plastically deform the metal sheet (4)  
 interposed therebetween when said sheet-  
 holding plate (6) is urged against said metal  
 sheet (4) before the welding operation is carried  
 out.
2. Apparatus according to claim 1, characterized in  
 that said supporting structure (2) and said sheet-  
 holding plate (6) are so shaped as to move a portion  
 of this metal sheet to be coplanar with the other  
 metal sheet on the side opposite to that facing  
 towards the laser focusing head (1), so as to nullify  
 said step (13) at said portion, while forming a step  
 on the opposite side of the metal sheets. 10
3. Apparatus according to claim 2, characterized in  
 that said supporting structure (2) is provided, at its  
 portion which is for receiving the metal sheet (4) to  
 be deformed, with an auxiliary element (5) shaped  
 according to the shape which must be given to the  
 metal sheet, the associated sheet-holding plate (6)  
 having a corresponding shape. 15 20 25
4. Method for butt-welding of planar metal sheets of  
 different thickness, by means of a laser beams, in  
 which there is provided a head for focusing a laser  
 beam, and in which two metal sheets of different  
 thickness which are to be welded to each other are  
 positioned for butt-welding, with their surfaces (3a)  
 facing towards the laser focusing head (1) lying in  
 the same plane and the opposite surfaces forming  
 a step (13), in which the laser focusing head (1) is  
 moved relative to the two metal sheets (3, 4) to be  
 welded, so as to move the laser beam along the  
 contact line (7) between the metal sheets (3, 4) so  
 as to weld the latter to each other, in which during  
 the welding operation the metal sheets (3, 4) are  
 held on a supporting structure (2) by means of two  
 sheet-holding plates (6), and in which said support-  
 ing structure (2) and at least one of said sheet-hold-  
 ing plates (6) are so shaped as to plastically deform  
 the metal sheet (4) interposed therebetween when  
 said sheet-holding plate (6) is urged against said  
 metal sheet (4) before the welding operation is car-  
 ried out. 30 35 40 45
5. Method according to claim 4, characterized in that  
 said metal sheet is deformed so as to move a por-  
 tion thereof to be coplanar with the other metal  
 sheet on the side opposite to that facing towards  
 the laser focusing head, so as to nullify said step  
 (13) while forming a new step on the side facing  
 towards the focusing head (1), at said portion of the  
 metal sheet. 50 55

Fig. 1

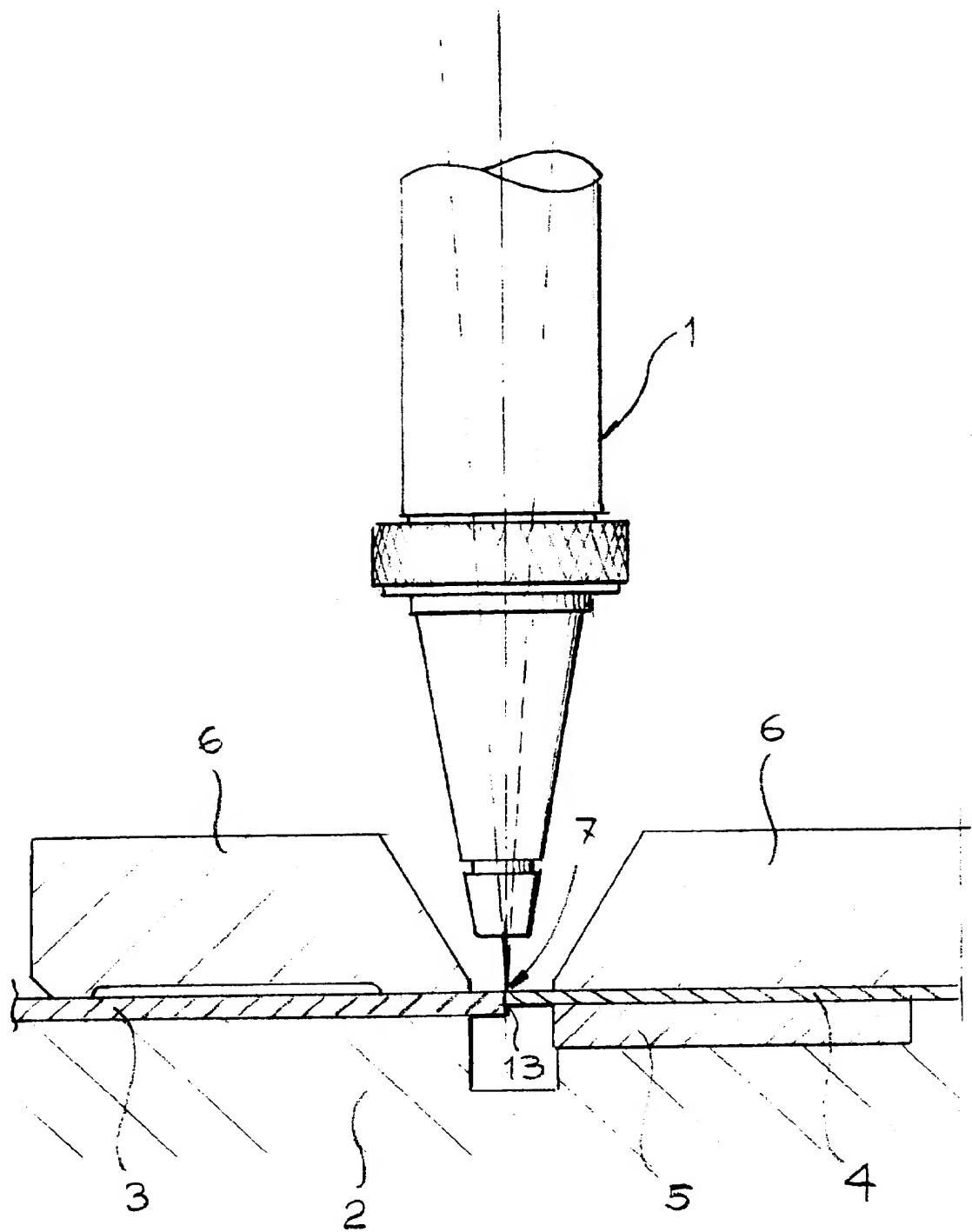


Fig. 2

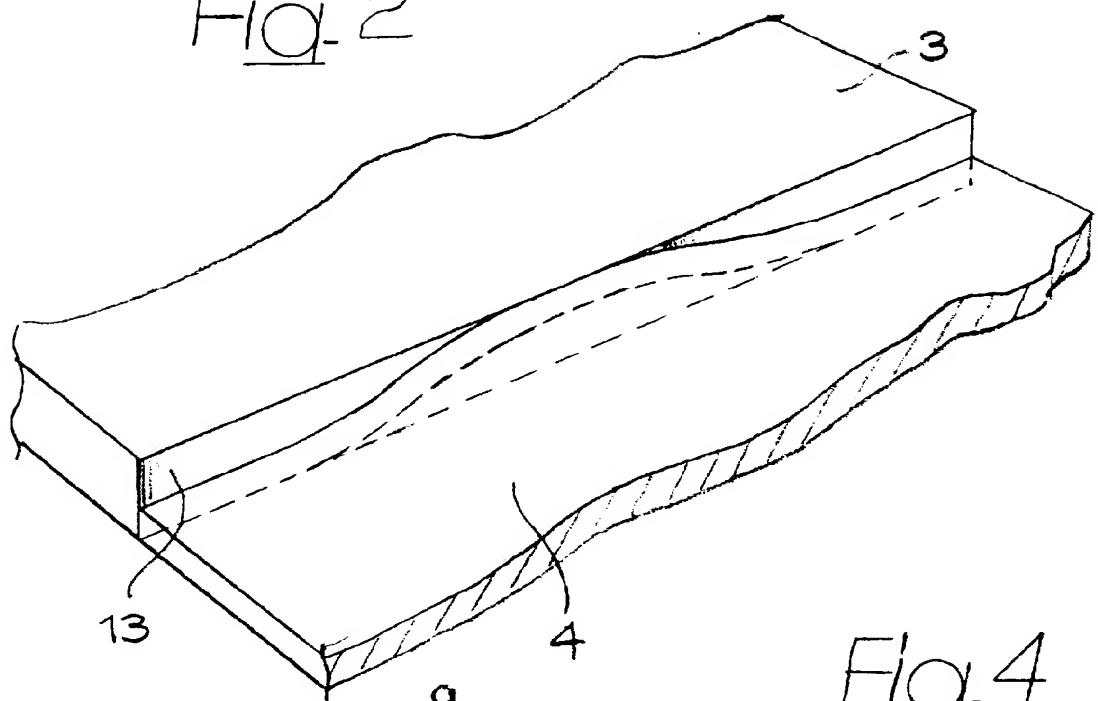


Fig. 3

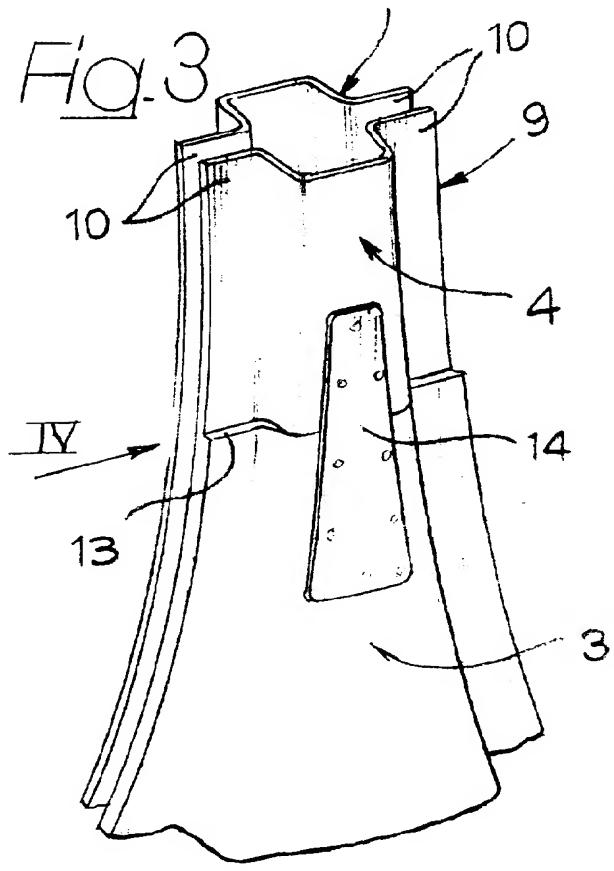


Fig. 4

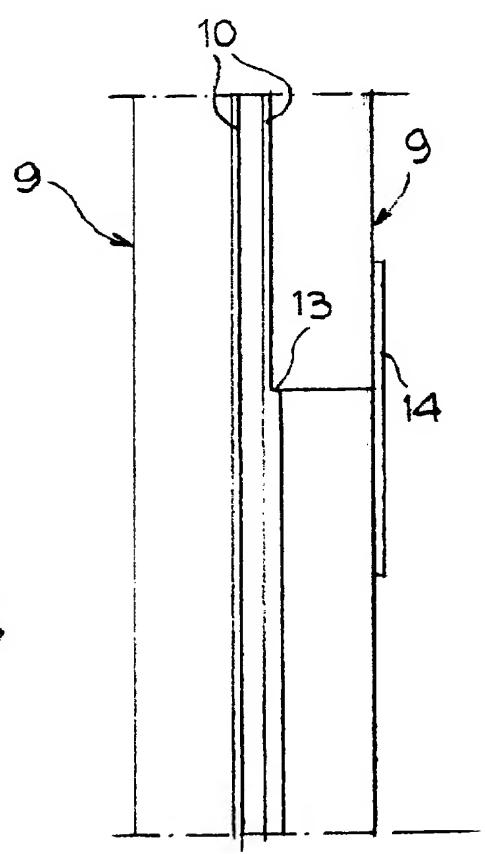


Fig. 5

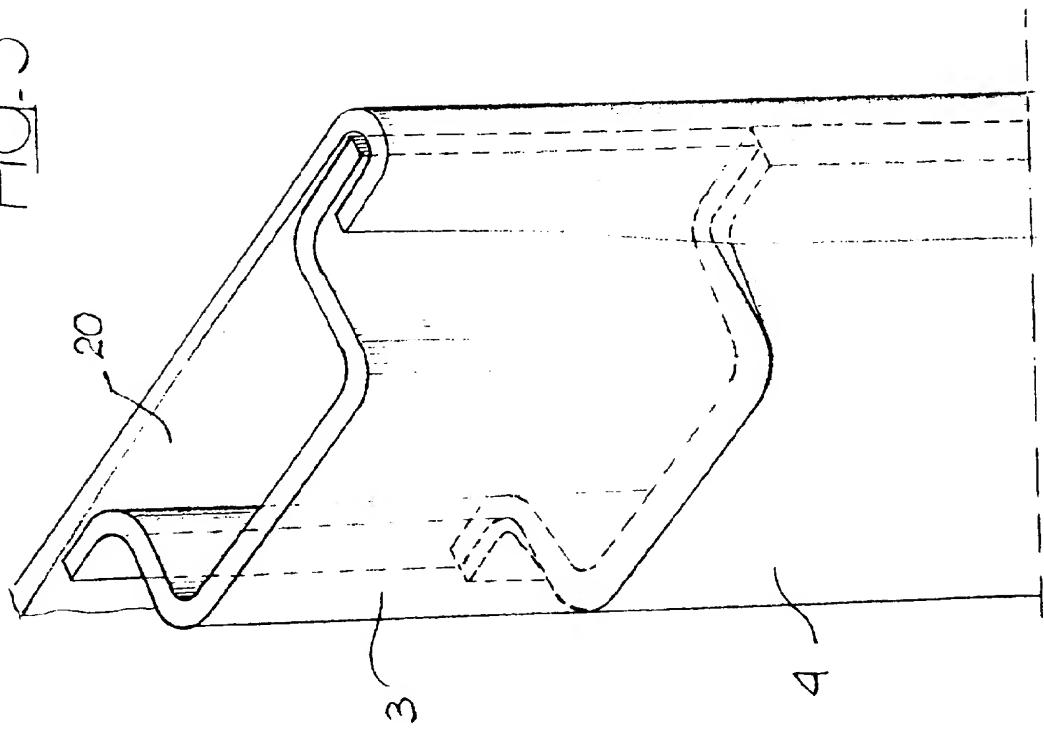
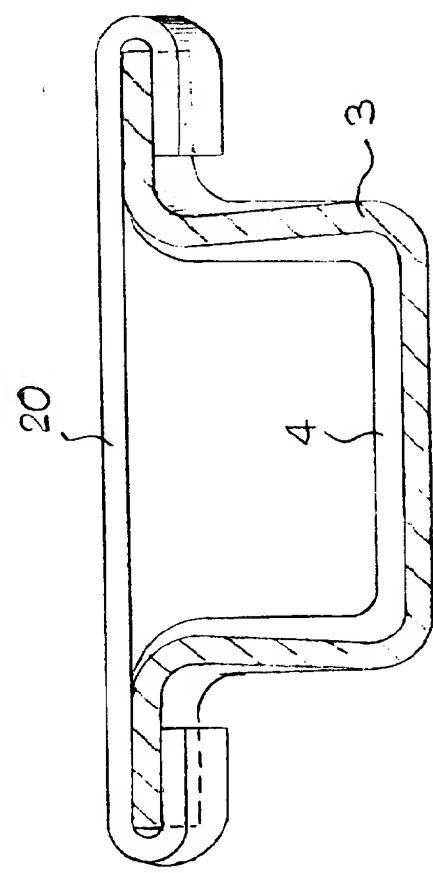


Fig. 6





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## EUROPEAN SEARCH REPORT

Application Number  
EP 95 83 0440

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	EP-A-0 565 846 (ELPATRONIC) * the whole document *	1,4	B23K33/00 B23K26/00
A	PATENT ABSTRACTS OF JAPAN vol. 6 no. 58 (M-122), 15 April 1982 & JP-A-57 001571 (TOPY IND LTD) 6 January 1982, * abstract *	1-5	
A	EP-A-0 326 994 (THYSSEN INDUSTRIE AG) * the whole document *	1,2,4,5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B23K
<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	21 February 1996	Aran, D	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			